THE DENVER
ENGINEERING WORKS
COMPANY
SHEPARD AND SEARING

BULLETIN NO. 1049
SUPERSEDING No. 1042

JULY 1, 1910

RICHARDS PULSATOR CLASSIFIER

INVERTED TYPE

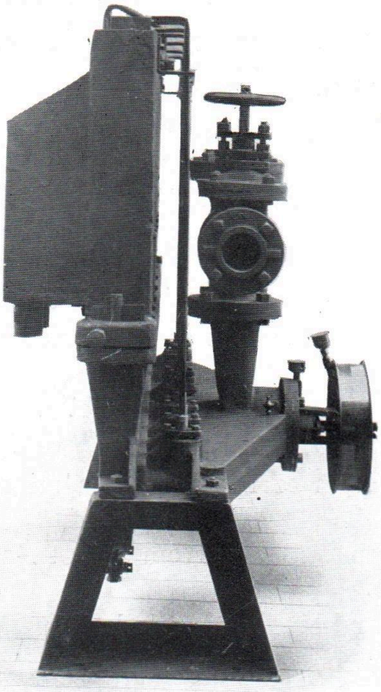


FIG. 882—170-TON 6-COMPARTMENT RICHARDS PULSATOR CLASSIFIER—INVERTED TYPE

RICHARDS PULSATOR CLASSIFIER

INVERTED TYPE

The Richards Pulsator Classifier is used to divide crushed ore pulps into several classified grades in the best possible condition to produce high recovery in a subsequent treatment on separate concentrating devices, allowing each device to be adjusted for its particular grade of pulp.

This machine was developed after extensive investigations with a great variety of ores and now after years of preparation and with the experience of many practical installations, we offer this improved machine as a reliable device in mill operations and one which produces the very best classifications for wet concentration of ores.

The modern type of reciprocating concentrating table is limited to the treatment of ore pulps not coarser than 1 mm. diameter, as larger particles will wear the table surface too rapidly.

Pulps coarser than 1 mm. diameter (about 12 mesh No. 19 wire) according to the best milling practice are now treated on jigs, while ore pulps finer than 1 mm. diameter are treated on concentrating tables or vanners.

While the Richards Pulsator Classifier is adapted to the classification of ore pulps varying from one to two mm. diameter particles down to 0, it has in actual practice treated ore pulps as coarse as 8 mm. and with special designs will treat ore pulps as coarse as 12 mm. or about ½ inch diameter.

RESULTS ACCOMPLISHED

Washes out fine slimes, first.

Classifies ore pulps into six and sometimes seven different grades.

Delivers classified pulps, each grade consisting of small particles of mineral and large particles of gangue.

Reduces losses in tailings of concentrating tables.

Increases capacity of concentrating tables.

Produces cleaner separation of mineral from mineral on each table, than with former methods.

Delivers clean shipping concentrates from spigot No. 7 without any further treatment on concentrating tables.

Washes ore thoroughly and breaks up any lumps.

Saves space over other forms of hydraulic classifiers.

The Richards Pulsator Classifier is patented in the United States and all the principal foreign countries.

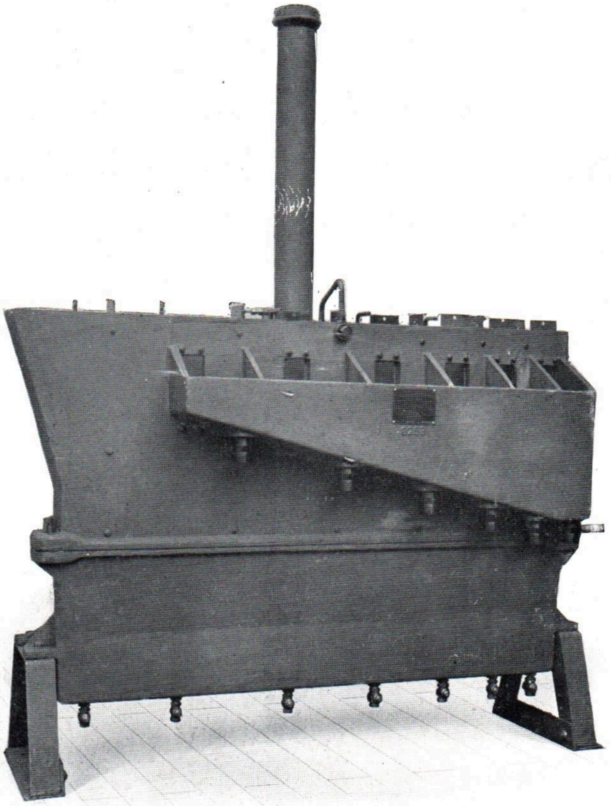


FIG. 883

4-INCH 6-COMPARTMENT RICHARDS PULSATOR CLASSIFIER—INVERTED TYPE—OPERATING SIDE

REMARKABLE SAVING IN VALUES

The most important improvement from using properly classified pulps is found in the recovery of values. In many cases high grade concentrates are collected in the hutch compartments of the classifier itself, below the screen.

Concentrating tables treating classified pulps from the Richards Pulsator Classifier will have a larger capacity than when treating pulps from older forms of hydraulic classifiers or when treating a screen sized pulp.

In one case the classifier catches amalgam of a large value every month, even after the battery pulp has previously passed over amalgam plates and mercury traps. In a western stamp mill the Richards Pulsator Classifier replaced an hydraulic classifier of obsolete pattern for classifying pulps to the coarse tables; the improvement in the recovery of values was so marked that a number of fine crushing devices together with a number of slime tables were shut down.

ELIMINATION OF FINE SCREENING

The great advantage of having screens in the mill no finer than 6 mesh will appeal to the practical mill man. The Richards Pulsator Classifier has repeatedly treated pulps as coarse as 2 mm. under actual mill conditions and therefore the necessity of screening finer than about 2 mm. is obviated by this remarkable machine. In a mill system comprising jigs for the coarse pulps and tables for the fine pulps, the screening need not be carried down finer than say 2 mm. (about 6 mesh), and then the classifier can be used on the pulps finer than 2 mm. down to 0.

With a mixed feed the table adjustments are always a compromise between a proper adjustment for the coarse and the fine grain, but exactly right for neither.

The results obtained from screen sized pulps are better than results obtained from a mixed feed, for with the screen sized pulps we have uniform sizes to deal with and the table adjustments may be made for that particular size, but the areas exposed to the flow of the wash water are equal, and the only influence tending to retard the mineral particles is the greater weight of the mineral particles.

Serious mechanical difficulties attend the screen sizing of table feed pulps.

Dr. Richards' papers, on "The Wilfley Table," read before The American Institute of Mining Engineers at the Toronto meeting, July, 1907, and at the New York meeting, February, 1908, state that repeated investigations show, that:

1st. A screen sized feed is better than a mixed, or unsized, feed.

2d. A good classified feed is better than a screen sized feed.

THE RICHARDS PULSATOR CLASSIFIERS ARE USED BY THE FOLLOWING COMPANIES:

Boston & Montana Cons. Copper & Silver Mining Co.	Great Falls, Montana
Tomboy Gold Mines Co.	Telluride, Colorado
El Tiro Copper Co.	Silver Bell, Arizona
Copper Creek Mining Co.	Copper Creek, Arizona
Vermillion Mining Co.	Silverton, Colorado
School of Mines, Columbia University	New York City
University of Washington	Seattle, Washington
Montreal Reduction & Smelting Co.	North Bay, Ontario
University of Toronto	Toronto, Ontario
Las Plomosas Mill	Chihuahua, Mexico.
Britannia Smelting Co.	Britannia Beach, B. C.
Milan Mining & Milling Co.	West Milan, N. H.
Colorado School of Mines	Golden, Colorado
O'Brien Mine	Cobalt, Ontario
Frontenac Mines Co.	Black Hawk, Colorado
Buffalo Mines Co.	Cobalt, Ontario
Original Amador Mines Co.	Amador, California
United States Smelting, Refining & Mining Co	Bingham Junction, Utah
University of California	Berkeley, California
Gold Prince Mines Co	Animas Forks, Colorado
Parral Consolidated Mines Co.	Parral, Mexico
Gold King Consolidated Mines Co.	Silverton, Colorado
Revenue Tunnel Mines Co.	Ouray, Colorado
Western Chemical Mfg. Co.	Denver, Colorado
Ledge Consolidated Mining Co.	Silverton, Colorado
American Zinc Extraction Co.	Leadville, Colorado
American Zinc Extraction Co.	Parral, Mexico

and others.

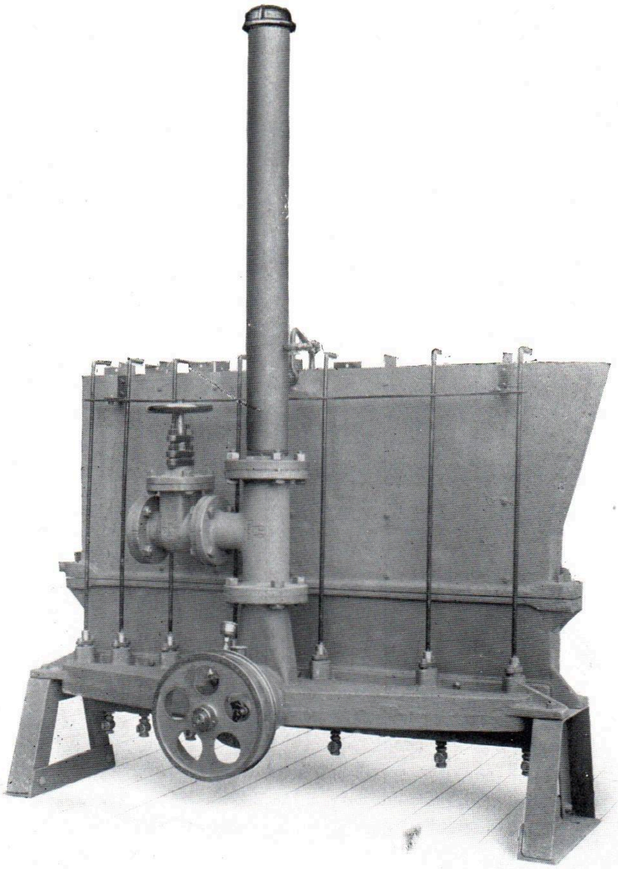


FIG. 881

4-INCH 6-COMPARTMENT RICHARDS PULSATOR CLASSIFIER—INVERTED TYPE—SHOWING PULLEY ON PULSATOR VALVE, WATER CONNECTION AND INDIVIDUAL REGULATING VALVES FOR EACH COMPARTMENT

RICHARDS PULSATOR CLASSIFIERS—SIZES—INVERTED TYPE

3-Inch Six Compartment.		4-Inch Six Compartment.	
Capacity	90 tons in 24 hours	Capacity	170 tons in 24 hours
Shipping weight	1,250 lbs.	Shipping weight	2,100 lbs.
Size of water pipe	2½ inches	Size of water pipe	3 inches
Size of pulley	12″ dia. x 2¾″ face	Size of pulley	12″ dia. x 2¾″ face
Revolutions per minute	160	Revolutions per minute	160
Code word	CANNIBAL	Code word	CALIPH

Capacity based on a feed of 3 parts water and 1 part ore by volume, ore crushed to pass 2 mm.

DESCRIPTION OF THE RICHARDS PULSATOR CLASSIFIER

INVERTED TYPE

The Richards Pulsator Classifier is the invention of Robert H. Richards, author of "Ore Dressing," and who has devoted many years to the study of hydraulic classification and treatment of ores. In his Pulsator Classifier is found the practical application of his great researches.

The type of classifier described in this bulletin is known as the "Inverted Type" for the reason that the fine slimes are delivered from the first compartment, whereas in the common form of hydraulic classifier the first compartment delivers the coarsest pulps. The Richards Pulsator Classifier thus "inverts" the order of grading the pulps.

Referring to Fig. 0223, the hydraulic water is delivered to the main gate valve, V. The pressure at which the hydraulic water should be delivered depends upon the size and specific gravity of the ore treated. A head of 20 ft. is required for copper ores carrying $2\frac{1}{2}$ mm. grains, or for galena ores carrying 2 mm. grains, while a head of 10 ft. will suffice for ores wherein the coarsest grains are 0.75 mm. in diameter (about 20 mesh). The hydraulic water then passes through the pulsating valve, B, by which the pulsating effect, which characterizes the machine, is obtained. A is an air cham-

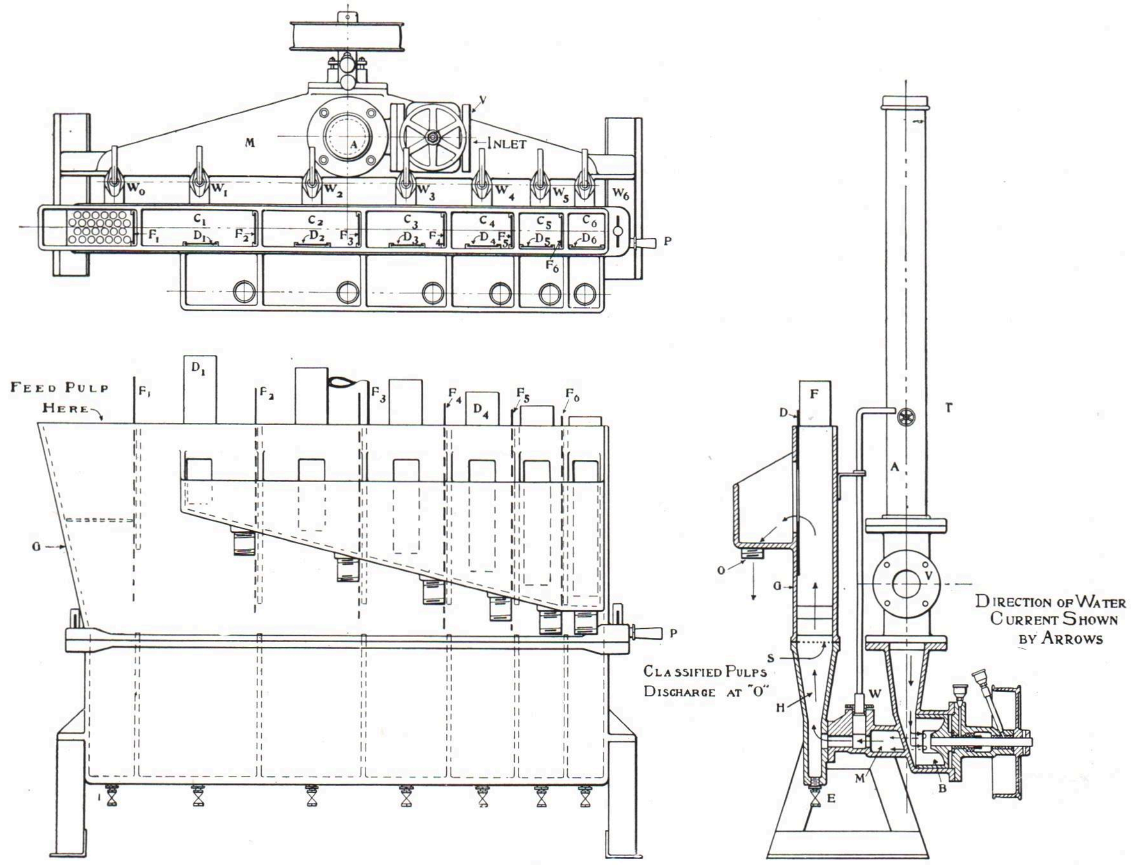


FIG. 0223

PLAN, ELEVATION AND SECTION—RICHARDS PULSATOR CLASSIFIER—INVERTED TYPE ber. The pulsating valve, B, connects with the manifold, M, which distributes the hydraulic water to each of the several compartments of the machine. Individual valves, W, control the supply of hydraulic water for each compartment.

The six classifying compartments, C_1 to C_6, are divided from each other by transverse walls, which correspond with the division walls in the hutch. Each division wall of the classifying compartments is provided with adjustable gates, F_1 to F_6, under which the ore passes from compartment to compartment.

The hydraulic water issues from the manifold under control of valves, W, into the hutch, then up to the sieve, S, as indicated by the arrows in the Section, Fig. 0223.

Referring to the Elevation of Discharge Side and the plan, Fig. 0223, it will be seen that the length of any hutch compartment and corresponding classifying compartment is greater than the length of any succeeding compartment.

We therefore have seven different ascending pulsating columns of water, the column in C_1 being of low velocity, in C_2 of relatively higher velocity, in C_3 of still higher velocity, and so on to C_6, where the column of water has the highest velocity of the seven columns.

The ore is introduced at feed compartment and falls to the sieve level, S, where it meets a rising pulsating current of water which agitates the ore, breaks up the lumps and prevents clogging of the feed compartment. From the feed compartment the ore passes under the gate F_1, where it meets and is subject to the action of the slowly rising, pulsating current of hydraulic water in C_1. This current further agitates the ore, lifts out and raises to the discharge gate D_1, the lightest, finest particles in the ore, whence they are discharged. Under the gate F_2 the ore feeds from classifying compartments C_1, on the sieve, S, to classifying compartment C_2, where, as explained above, it is subjected to a more swiftly pulsating current of hydraulic water which continues the agitation set up in the feed compartment and compartment C_1, and lifts out of the ore bed the next heavier particles, which are raised to and discharged through D_2. This process is repeated, successively in compartments C_3, C_4, C_5 and C_6. In the last compartment, only the heaviest particles will have been left in the ore bed and these are discharged from D_6. In the event that the ore contains particularly heavy particles, the current in C_6 may not be sufficient to lift all the ore to D_6, in which event the spigot, P, is used. In the majority of cases when it is necessary to use the spigot, P, the discharge therefrom will be found to be excellent concentrates.

The gate, D_1, is considerably higher than D_6. Hence the water in the machine tends to flow towards D_6, thus washing the ore along the sieve, S, to the final discharge opening D_6 or P, as the case may be. Gates, D, are provided for varying the height of the discharge openings within wide limits.

Properly adjusted, the Richards Pulsator Classifier will discharge all the slimes in the ore from the first two discharge openings, D_1 and D_2.

The sieve, S, serves only to support the bed of ore and has no part in the classification. Particles of free mineral of sufficient size to settle against the classifying current in the compartments, but finer than the mesh screen S may occur in the feed, will sink through the screen S to the bottom of the hutch whence they may be drawn off as a rich concentrate through the spigots shown. Often a very high grade concentrate may be obtained from the hutch spigots.

FREE SETTLING AND HINDERED SETTLING

The hydraulic classification of ore pulps comprises two methods, one known as "free settling" and the other as "hindered settling."

"Free settling" is where individual particles fall freely, either in still water, or against an opposing upward current, without being hindered by other particles. Spitzkasten, or pointed boxes, and settling tanks are examples of this principle.

"Hindered settling" exists where particles of mixed shapes, sizes and gravities, in a mass, yet free to move among themselves, are sorted in a rising current of water. Hindered settling is affected by the same qualities that influence free settling. There is an additional effect of crowding grains closely together so that grains of the same specific gravity will be arranged according to size; the smallest rising to the top and the largest grain falling to the bottom. In mixed sizes of minerals of different specific gravities, a small grain of mineral will arrange itself on a level with a larger grain of gangue, but the ratio between the diameter of this mineral particle and its associated gangue particle is much greater than exists under free settling conditions. For example, under free settling conditions, a particle of galena will settle with a quartz particle whose diameter is 3½ times as great. Under hindered settling conditions a particle of galena will settle with a quartz particle whose diameter is 6½ times as great.

Assume an ore consisting of but two elements, galena and quartz, and after crushing same to a suitable size, feed this pulp to the common form of "Spitzkasten" or pointed box classifier of the "free settling" type; then a particle of galena 1 mm. in diameter will fall through the water with a particle of quartz 3.5 mm. diameter—and this ratio of the diameter of the galena particle 1 to 3.5 is the "free settling" ratio for galena and quartz.

Feeding the same galena-quartz ore to a Richards Pulsator Classifier will, by means of the pulsating current, subject the ore to "hindered settling" conditions, and a particle of galena 1 mm. diameter will fall through the pulsating current with a particle of quartz 6.5 mm. diameter. This ratio of 1 to 6.5 is the "hindered settling" ratio for galena and quartz.

Thus the "hindered settling" conditions in the Richards Pulsator Classifier deliver from each classifier compartment a pulp in which the gangue particles are nearly twice as large as would be the conditions under "free settling." This increase in the diameter of the gangue particle has an important bearing on the increased recovery of values and particularly in the separation of one mineral from another on the same table.

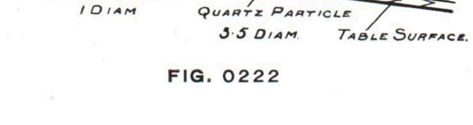


FIG. 0222

This figure shows the condition on the surface of a concentrating table with ore pulps classified under free settling conditions. The galena particle 1 unit diameter lies in a lower strata of wash water the velocity of which is retarded owing to its friction on the surface of the table. The quartz particle 3.5 units diameter projects farther up into the stream of wash water where the velocity is higher. As the quartz particle is 3.5 times the diameter of the galena particle the area exposed by the quartz particle to the transporting power of the wash water is over twelve times the area exposed by the galena particle, hence the quartz particle is moved down the table surface with the wash water leaving the galena particle behind.

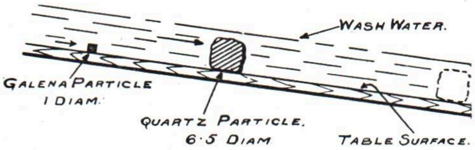


FIG. 0221

This figure shows the condition on the surface of a concentrating table with pulps classified under "hindered settling" conditions (such as in the Richards Pulsator Classifier), namely, galena and quartz particles with diameters in the ratio of one to six and one-half (1 to 6.5). Under these conditions the quartz particles present an exposed area over *42 times* the exposed area of the galena particle and therefore the quartz particle is washed a greater distance from the table than is the case where free settling conditions exist.

TABLE REPLACING FINE JIGS

Formerly the Harz type of jig has been used to concentrate pulps as fine as 30 or 40 mesh, which requires great attention to jig adjustments and best possible conditions for reasonable recovery of values. With a feed as fine as 30 or 40 mesh delivered to a Harz jig there is a tendency for fine mineral to escape with the tailings and by increasing the suction to prevent this loss fine gangue is drawn down into the hutch product.

With properly classified pulp a good reciprocating table may handle pulps as coarse as 1 mm. very successfully. With the Richards Pulsator Classifier ore pulps as coarse as 2½ mm. have been treated successfully. Tables require less water than Harz jigs, the adjustments are simpler and easier and power is saved.

ADVANTAGES OF PULSATING CURRENT OF WATER

The Richards Pulsator Classifier uses an intermittent, sharp, pulsating current of water without a suction cycle in producing the hindered settling conditions, which is remarkably quick in its action of breaking up any masses of ore particles which have previously been packed together. Under ordinary methods of classification a fine mineral particle may become attached to the surface of a large particle of gangue, but the sharp, pulsating current prevents such a condition; any fine mineral particle is washed free from the gangue particle, and all classified pulps are delivered with proper relation of sizes between mineral and gangue particles.

WASHING ORE

There are some ores which require only a washing, with possibly some classification, previous to their being shipped to market, such as iron ores, phosphate rock, barytes, fluorspar, etc., and whenever the physical structure and specific gravity of the various elements in combination will allow separation the Richards Pulsator Classifier may be adapted to such special lines of treatment sometimes without the need of subsequent treatment on concentrating tables or similar systems.

IDEAL FEED FOR HARZ PLUNGER JIGS

Under certain mill conditions the common Harz plunger type of jig may be used on the coarse classified pulps of the Richards Pulsator Classifier. Generally the classifier discharge gates 1 to 4 inclusive deliver classified pulps to tables and vanners, but sometimes the discharge gates 5 and 6 and spigot 7 deliver classified products so coarse that the wear on the table surface is excessive, and on this account the Harz type of jig is better adapted to handle these products.

The pulps from the Richards Pulsator Classifier consist of small particles of mineral and large particles of gangue, hence in the bed of a Harz jig the suction stroke draws the fine mineral down through the spaces between the large gangue particles and through the screen into the hutch.

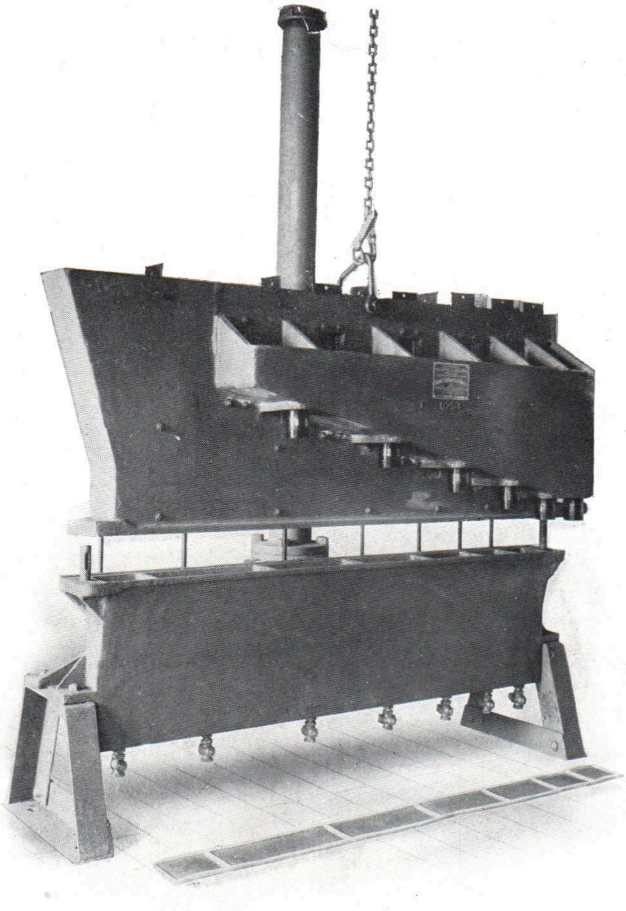


FIG. 884

4-INCH 6-COMPARTMENT CLASSIFIER—SHOWING HOW UPPER PART MAY BE RAISED FOR REMOVING SCREEN. DRIVING KEYS FROM ONE KEY-BOLT AT EACH END IS ALL THAT IS NECESSARY TO BREAK THE JOINT—SCREEN WITH GASKET VULCANIZED TO IT IS SHOWN ON THE FLOOR

CLASSIFICATION AT EL TIRO MILLS

Pima County, Arizona—Working Results of the Richards Pulsator Classifier—Comparison of Classified with Screen Sized Material

The Richards Pulsator Classifier, perfected by Prof. Robert H. Richards, of the Massachusetts Institute of Technology, undoubtedly marks a distinct advance in the science of ore dressing, for of all the problems encountered in concentration, the one of suitable classification has been the most troublesome and until the advent of this classifier, the least satisfactorily overcome.

* * * * * * * * * * * *

TABLE 1. SIZE AND MESH OF SCREENS USED

No. OF SCREENS	MESH	Opening in Inches	Opening in Milli-meters
1	10	.78	2.00
2	29	.036	1.00
3	30	.024	.61
4	40	.0112	.30
5	80	.00675	.17
6	100	.00550	.14
7	150	.00360	.092
8	200	.00300	.077

At the mill of the El Tiro Co. is a standard 4-inch machine rated by Professor Richards *at from 150 to 200 tons per 24 hours.* By making the adjustments above noted, the thickness of the bed on the sieve was made equal to that carried under full capacity and the capacity of our machine was successfully reduced to *30 tons per 24 hours at which it did satisfactory work.* The results given below were attained on a porphyritic ore, carrying disseminated black oxide of copper averaging approximately 2.25 per cent. copper, the mineral being exceedingly soft and easily slimed.

In order to make a comparative series of tests of the relative merits of screen sizing and classifier sizing, two quantities of the same ore were crushed under exactly similar conditions.

Table 1 shows size and mesh of screens used:

A screen analysis of a representative quantity of the crushed ore gave the following:

Through screen No. 1, on screen No. 2, 40 per cent., no free mineral, all reground; through screen No. 2, on screen No. 3, 21 per cent., table tailings reground; through screen No. 3, on screen No. 4, 14 per cent., table tailings to waste; through screen No. 4, on screen No. 5, 10 per cent., table tailings to waste; through screen No. 5, 15 per cent., table tailings to waste.

The 40 per cent. of the crushed ore passing screen No. 1 but caught on screen No. 2 (20 mesh or 1 mm.) contained no free mineral but enough disseminated mineral to require recrushing before sending to the concentrating tables.

The next finer sized material caught on screen No. 3 (30 mesh or .61 mm.) and comprising 21 per cent. of the total quantity, after concentration on the tables had so much mineral in the tailings as to necessitate regrinding. The tailings from the tables treating the finer sizes were sent to waste.

Thus the method of *screen sizing* the mineral before table concentration *required the regrinding of 61 per cent.* of the total before attaining the desired per cent. recovery.

To obtain this same recovery using the *Richards Pulsator Classifier* instead of the screens, *it was found necessary to regrind but 46 per cent. of the total* concentrating table tailings, and the feed for these particular tables came from classifier compartments Nos. 5 and 6. The reduction in the amount of material to be reground is apparent in the screen analysis below where it is seen that a considerable portion of coarse material, practically valueless (below 1 per cent. copper) was drawn from compartments Nos. 3 and 4. The advantage of using the classifier over the screen is thus apparent.

From the accompanying screen analyses, made by the writer, the character of the work of the classifier is made apparent.

	Discharge from											
	Compartment 1		Compartment 2		Compartment 3		Compartment 4		Compartment 5		Compartment 6	
Size of Screen	Per Cent. on Screen	Per Cent. Copper	Pet Cent. on Screen	Per Cent. Copper	Per Cent. on Screen	Per Cent. Copper	Per Cent. on Screen	Per Cent. Copper	Per Cent. on Screen	Per Cent. Copper	Per Cent. on Screen	Per Cent. Copper
2					6.00	.76	12.00	.55	52.00	.67	62.00	1.32
3			5.00	.60	23.50	.78	36.00	.84	40.00	1.51	29.50	1.66
4	8.20	.60	30.00	.77	49.00	1.01	37.35	.94	7.40	6.00	7.00	5.80
5	22.70	1.02	29.00	1.50	15.50	4.14	11.00	5.94			1.20	15.24
6	13.70	1.35	7.50	2.40	2.50	8.34	1.50	9.50				
7	10.20	1.79	10.00	2.55	2.50	10.02	2.50	7.74				
8	10.50	2.19	5.00	3.36								
9	35.00	1.95	15.00	1.98								

The test from which these analyses were taken was made in part to determine how early in the process all slimes could be drawn off. As shown by the table, this was done in the first two compartments. *The water discharging from the last four was quite clear and practically free of mineral too fine to be recovered from the associated coarser quartz grains. The only apparent free mineral loss took place on the tables receiving the discharges of the first two compartments.*

It is a matter of general knowledge that classification effects a greater saving in proportion as it approaches the theoretically perfect, therefore it is useless to compare recoveries made by treating classified as against unclassified material. We have, however, made the tests noted above, to compare material classified with the Richards pulsator, with screen-sized material. As a result we found that there was practically *no choice between them from the standpoint of recovery made, but when cost of installation, power, and maintenance are considered, the classifier has much the best of it.* No assumption is intended that this will hold true as a general proposition with all ores and under all conditions, for it most probably would not. In any event it is the wisest procedure to determine this in each particular instance.

In conclusion I might sum up the advantages of this machine as follows: Small floor space required; small loss of mill head; wide range of capacity and the delivery of six products. This last is by far the most important, for not only is the pulp divided into six classes, but is also segregated in such a way that that part of the pulp which might be further treated after passing the concentrators is separately available, *i. e.*, the table tailings of the coarse sizes might be profitably reground, while the finest can be sent on to the slime plant. *In short, it opens a wider field for the chasing of values, and will surely lower the "irreducible minimum" below which it would be unprofitable to follow.* It must be understood, however, that this machine, admirable as it is, cannot entirely overcome the ill effects of poorly advised methods of grinding, or subsequent treatment of its product. It will work to best advantage only when the general scheme of treatment is logical, from the entrance of the ore into the mill, to its exit by way of the concentrates bin and waste tailings launder.

SANTA RITA MINING COMPANY

This company operates at Santa Rita, near Silver City, New Mexico. The following data, compiled by Mr. John M. Sully, manager, shows very clearly the work of the Wilfley tables following our classifier on a copper ore crushed to pass 20 mesh screens. The report is of great interest as it shows the work of the classifier on finely crushed ores, and is worth the very careful study that is required to fully comprehend just what is shown therein.

TEST ON CHINO DUMP — MARCH 3RD 1909
SANTA RITA MINING CO.
RICHARDS PULSATOR CLASSIFIER — WILFLEY CONCENTRATING TABLES
GENERAL FEED SAMPLE 2.33% Cu. GENERAL TAILS SAMPLE 0.49% Cu.

CLASSIFIER DISCH. No.	TABLE No.	CLASS		ORIGINAL SAMPLE		+20 MESH	-20+30 MESH	-30+40 MESH	-40+50 MESH	-50+60 MESH	-60+80 MESH	-80+100 MESH	-100+150 MESH	-150+200 MESH	-200 MESH	CONCTS % Cu.
				BY ASSAY	BY CALCULATION											
6	1	FEED	% Size	100	— —	TRACE	36	15	22	13	5	+8	— —	— —	— —	17.9
"	"	"	% Cu.	2.22	2.03	— —	0.99	1.25	1.98	3.06	3.71	5.84	— —	— —	— —	
"	"	"	% Total Cu. by Weight	— —	100	— —	17.6	9.2	21.5	19.6	9.1	23.0	— —	— —	— —	
"	"	TAILS	% Size	100	— —	TRACE	41	18	23	11	4	+3	— —	— —	— —	
"	"	"	% Cu.	0.36	0.36	— —	0.30	0.38	0.44	0.40	0.36	0.40	— —	— —	— —	
"	"	"	% Total Cu. by Weight	— —	100	— —	33.9	18.8	27.9	12.1	4.0	3.3	— —	— —	— —	
"	2	FEED	% Size	100	— —	TRACE	30	12	23	14	6	6	5	+3	— —	17.1
"	"	"	% Cu.	2.51	2.65	— —	1.81	1.60	2.28	2.97	3.54	5.09	5.63	5.95	— —	
"	"	"	% Total Cu. by Weight	— —	100	— —	20.5	7.2	19.8	15.7	8.0	11.5	10.6	6.7	— —	
"	"	TAILS	% Size	100	— —	TRACE	34	18	23	14	5	+5	— —	— —	— —	
"	"	"	% Cu.	0.42	0.36	— —	0.32	0.40	0.44	0.36	0.34	0.27	— —	— —	— —	
"	"	"	% Total Cu. by Weight	— —	100	— —	30.0	19.8	27.9	13.9	4.7	3.7	— —	— —	— —	
5	3	FEED	% Size	100	— —	TRACE	22	12	22	19	7	7	7	+4	— —	16.3
"	"	"	% Cu.	1.98	1.65	— —	0.85	0.82	1.03	1.58	2.43	2.80	4.38	5.21	— —	
"	"	"	% Total Cu. by Weight	— —	100	— —	8.7	6.0	13.7	18.2	10.3	11.9	18.6	12.6	— —	
"	"	TAILS	% Size	100	— —	TRACE	27	13	23	18	6	6	+7	— —	— —	
"	"	"	% Cu.	0.38	0.34	— —	0.23	0.38	0.38	0.42	0.42	0.34	0.34	— —	— —	
"	"	"	% Total Cu. by Weight	— —	1.00	— —	18.1	14.4	25.4	22.0	7.3	5.9	6.9	— —	— —	
"	4	FEED	% Size	100	— —	— —	21	14	24	16	8	8	5	+6	— —	12.8
"	"	"	% Cu.	2.26	1.92	— —	0.88	1.20	1.41	1.94	2.79	2.86	4.10	4.43	— —	
"	"	"	% Total Cu. by Weight	— —	100	— —	9.4	8.8	17.7	16.0	11.6	11.9	10.7	13.9	— —	
"	"	TAILS	% Size	100	— —	TRACE	23	15	23	20	7	7	+8	— —	— —	
"	"	"	% Cu.	0.29	0.32	— —	0.34	0.36	0.32	0.32	0.19	0.23	0.28	— —	— —	
"	"	"	% Total Cu. by Weight	— —	100	— —	24.8	17.1	23.3	20.2	4.2	5.1	5.3	— —	— —	
4	5	FEED	% Size	100	— —	— —	10	9	20	18	10	11	11	5	6	15.1
"	"	"	% Cu.	1.92	1.83	— —	0.55	0.68	0.87	1.22	1.79	2.13	3.59	4.85	4.52	
"	"	"	% Total Cu. by Weight	— —	100	— —	3.0	3.3	9.5	12.0	9.8	12.8	21.5	13.2	14.8	
"	"	TAILS	% Size	100	— —	TRACE	18	10	21	17	8	9	9	+8	— —	
"	"	"	% Cu.	0.57	0.34	— —	0.34	0.30	0.30	0.36	0.42	0.42	0.23	0.42	— —	
"	"		% Total Cu. by Weight	— —	100	— —	17.9	8.8	18.4	17.9	9.9	11.1	6.1	9.9	— —	
3	6	FEED	% Size	100	— —	— —	TRACE	5	8	15	9	17	24	8	15	16.3
"	"	"	% Cu.	1.75	1.81	— —	— —	0.61	0.65	0.59	0.80	1.16	2.47	3.50	3.36	
"	"	"	% Total Cu. by Weight	— —	100	— —	— —	1.7	2.9	4.9	3.9	10.8	32.6	15.4	27.8	
"	"	TAILS	% Size	100	— —	— —	TRACE	6	11	17	9	18	23	7	10	
"	"	"	% Cu.	0.32	0.34	— —	— —	0.28	0.25	0.28	0.30	0.30	0.34	0.25	0.64	
"	"	"	% Total Cu. by Weight	— —	100	— —	— —	5.0	8.2	14.2	8.0	16.1	23.3	5.2	20.0	
1 + STEEL TANK PULP	7	FEED	% Size	100	— —	— —	— —	TRACE	2	5	5	11	26	14	36	15.6
"	"	"	% Cu.	1.41	1.43	— —	— —	— —	0.95	0.57	0.48	0.51	0.99	1.57	2.28	
"	"	"	% Total Cu. by Weight	— —	100	— —	— —	— —	1.3	2.0	1.7	3.9	18.0	15.4	57.7	
"	"	TAILS	% Size	100	— —	— —	— —	— —	TRACE	6	3	12	18	13	46	
"	"	"	% Cu.	0.84	0.85	— —	— —	— —	— —	0.89	0.61	0.44	0.36	0.42	1.31	
"	"	"	% Total Cu. by Weight	— —	100	— —	— —	— —	— —	6.3	2.2	6.2	7.7	6.5	71.1	
2	8	FEED	% Size	100	— —	— —	— —	— —	TRACE	5	8	16	27	16	28	8.0
"	"	"	% Cu.	1.25	1.53	— —	— —	— —	— —	0.33	0.40	0.57	0.99	1.71	3.02	
"	"	"	% Total Cu. by Weight	— —	100	— —	— —	— —	— —	1.1	2.1	6.0	17.5	17.9	55.4	
"	"	TAILS	% Size	100	— —	— —	— —	— —	TRACE	9	9	15	28	8	30	
"	"	"	% Cu.	0.59	0.63	— —	— —	— —	— —	0.33	0.36	0.36	0.42	0.49	1.18	
"	"	"	% Total Cu. by Weight	— —	100	— —	— —	— —	— —	4.8	5.2	8.6	18.8	6.1	56.5	
— STEEL TANK PULP	9	FEED	% Size	100	— —	— —	— —	— —	— —	— —	2	6	16	16	60	10.2
"	"	"	% Cu.	1.23	1.23	— —	— —	— —	— —	— —	(0.70)		0.55	0.68	1.63	
"	"	"	% Total Cu. by Weight	— —	100	— —	— —	— —	— —	— —	4.6		7.1	8.8	79.5	
"	"	TAILS	% Size	100	— —	— —	— —	— —	— —	— —	— —	4	24	21	51	
"	"	"	% Cu.	0.70	0.71	— —	— —	— —	— —	— —	— —	0.67	0.40	0.38	1.00	
"	"	"	% Total Cu. by Weight	— —	100	— —	— —	— —	— —	— —	— —	3.8	13.5	11.2	71.5	
STEEL TANK OVERFLOW	10	FEED	% Size	100	— —	— —	— —	— —	— —	— —	TRACE	4	6	6	84	7.6
"	"	"	% Cu.	1.58	1.60	— —	— —	— —	— —	— —	— —	(1.56)		(1.60)		
"	"	"	% Total Cu. by Weight	— —	100	— —	— —	— —	— —	— —	— —	9.8		90.2		
"	"	TAILS	% Size	100	— —	— —	— —	— —	— —	— —	TRACE	12	6	8	72	
"	"	"	% Cu.	1.33	1.33	— —	— —	— —	— —	— —	— —	1.46	1.27	1.16	1.37	
"	"	"	% Total Cu. by Weight	— —	100	— —	— —	— —	— —	— —	— —	13.2	5.7	7.0	74.1	

DENVER ENGINEERING WORKS Co.
3/27/09

The classifier is a standard 4-inch 6-compartment machine of the inverted type. Discharge No. 6 is therefore the coarsest product of the classifier.

Despite the fineness of the feed, note the absence of fine free mineral in the tailings of table Nos. 1 to 6 inclusive. This shows clearly the elimination of fine free mineral from the tailings that is accomplished by the pulsator classifier under proper operating conditions, and the consequent fact: that only by recrushing could any further saving be effected.

As an example, consider the tailings of table No. 4. If we assume the general sample of these tailings as 1,000 lbs. then the total sample contains but 32 pounds of copper while the portion of these tailings that passes through a 60-mesh screen carries but 4.2% + 5.1% + 5.3% = 14.6% of 32 lbs. = 4.672 lbs. of copper out of 1,000 lbs. of tailings is lost in material finer than 60 mesh.

We can conceive of no more conclusive proof, than that set forth in this table, of our claim that the pulsator classifier will eliminate absolutely fine free mineral from coarse table tailings.

In connection with Mr. Sully's report, the following extracts from his letters will also be of interest.

March 4, 1909. "The classifier has been doing most excellent work for us."

March 31, 1909. "I have noted the surprising saving in the meshes between 40 and 100. It seems to hold true on every test that we have made, on all classes of ore."

April 23, 1909. "Our boys who are handling the classifier in the mill have attained great proficiency in it, and I am satisfied that a test on it at this time would show even better results than those sent you * * * I feel more than satisfied with the results that we have accomplished in this mill in connection with the use of Dr. Richards' two machines."

BOSTON & MONTANA C. C. & S. M. CO.

This company, operating at Great Falls, Montana, purchased one standard 4-inch 6-compartment pulsator classifier April 6, 1907. Three more machines of the same size and type were ordered November 18, 1907.

In this installation the classifiers are fed with the undersize of 2½ mm. trommels. (Approx. 5 mesh.)

In a letter to Prof. Henry S. Munroe, under date of February 10, 1909, Mr. Charles W. Goodale, general manager of the Boston and Montana C. C. & S. M. Co., says:

> "The classifiers were first installed with the belief that they would do better work than the * * * type of classifier, which was in general use in our concentrator, and was treating the undersize of 2½ mm. trommels and the Huntington mill product, making four jig classes, and an overflow slime for the Wilfley tables. As first installed, the six different classes from the Richards machine were treated on six separate Wilfley tables. The tailing from the coarser sizes going to the Huntington mills for recrushing, and the finer sizes giving tailing which was run over * * * screens, 50 mesh, the oversize from which was found to be too low grade for further treatment, but the undersize went to Frue vanners where an important additional saving was made. After a few months experience it was found that the coarse sizes, which were naturally just under 2½ mm., that being the screen which prepared the feed for the classifier, were too coarse for the Wilfleys, the cutting and wearing of the riffles and decks being excessive. Harz jigs were then installed for treating these coarse sizes, and are giving very clean concentrate, with tailing carrying included grains and requiring further crushing.
>
> "The points of advantage of the pulsator classifier over the * * * are as follows:

"1st. Better classification. This enables us to send to jigs or tables only that size of grains which the different kinds of machines are adapted to handle, and avoids as far as possible the recrushing of mineral grains which are already free.

"2nd. Less water than with the * * * classifier, thereby giving a reduced volume of slime to be treated or settled."

In another letter written to Dr. Richards, under date of January 28, 1909, Mr. Goodale says: "Mr. H. D. McLeod wrote me, under date of January 11, asking for the latest information regarding the classifier * * *. I have replied to Mr. McLeod's letter * * * and have strongly endorsed the classifier."

BRITANNIA MINING AND SMELTING CO.

This company operates at Britannia Beach, British Columbia, and in remodeling their concentrating mill installed three 4-inch 6-compartment pulsator classifiers of the inverted type. These machines were shipped January 30, 1909.

Their ore is crushed to pass ¾-inch round holes, then screened for jigs and the undersize of the 1 mm. (Approx. 12 mesh) screens goes to the classifiers. Coarse jig middlings are recrushed to pass ¼ inch, and the 1 mm. and finer from these also goes to the classifier, while the medium jig middlings are crushed to pass 2 mm. and go directly to the classifiers.

In a letter of March 4, 1909, to Dr. Richards, Mr. Robert H. Leach, general superintendent of the Britannia M. & S. Co. says: "In my opinion the Richards Jig and Pulsator Classifiers will do far more for the art of ore dressing than the reciprocating table has done."

In another letter of July 9, 1909, also to Dr. Richards, Mr. Leach says, "the classifiers are doing most excellent work."

TOMBSTONE CONSOLIDATED MINES, Ltd.

With reference to the operation of a standard 2-inch 6-compartment Richards Pulsator Classifier in operation at this company's plant at Tombstone, Arizona, the mill foreman, Mr. John H. Kohler, reports: "We are separating lead, zinc and iron and get the zinc up to 45 per cent. Richards Pulsator Classifier is surely a wonderful little machine and we could hardly do without it in our plant here."

We are informed that prior to installation of the classifier it was impossible to obtain a zinc concentrate assaying higher than 19 per cent.

CASHIER MINING AND MILLING CO.

This company operated at Camp Albion, Boulder County, Colorado. The ore carries gold, silver and lead, while gangue is of a complex nature.

Their ore averages from 8 to 10 per cent. lead. The following assays of table products furnished by Mr. Wood, are of interest:

Table Concentrates—42.2% Pb., 21 oz. Ag., 0.7 oz. Au.
Table Tailings—Trace Pb., 0.6 oz. Ag., 0.2 oz. Au.
Middlings—6.6% Pb., 3.8 oz. Ag. 0.4 oz. Au.

TOMBOY GOLD MINES, Ltd.

The ore which this company treats in its 60-stamp mill at Telluride, Colorado, is of a very complex nature, as it carries free gold, silver and lead values as well as zinc blendes and iron.

About three years ago especial attention was given the preparation of the feed to the concentrating tables and for this purpose there were installed:

3 Belt and Bucket Elevators, each 55 feet c to c.
6 50-Mesh Special Screens.
6 120-Mesh Special Screens.
Estimated cost, installed, $8,000.

Owing to cost of maintenance upon the elevator and screens a standard 4-inch 6-compartment Richards Pulsator Classifier was purchased for experimental purposes in May, 1908. At first there was some doubt whether the classifier would operate successfully on this very fine pulp, but after several months experimental work, three more classifiers were installed, replacing the elevators and screens.

The installation at the Tomboy, therefore, now consists of
3 Spiral Sand Pumps, working against approx. 18 ft. head.
4 4-inch 6-compartment Richards Pulsator Classifiers.
Estimated cost, installed, $5,500.

In July, 1909, Dr. Richards visited the Tomboy mill and found that despite the fineness of the pulp fed to classifiers, the classified feed to tables treating discharges Nos. 6, 5 and 4 carried no slimes whatever, the table performances as a whole being as follows:

Table on Discharge No. 6. Feed carries no slimes. Tailings screened on 100-mesh screen. Undersize vanned and showed no free mineral.

Table on Discharge No. 5. Feed carries no slimes. Tailings screened on 200-mesh screen. Undersize vanned and showed no free mineral.

Table on Discharge No. 4. Same result as on table treating No. 5.

Table on Discharge No. 3. Feed carried small amount of slime. Tailings screened on 200-mesh screen. Undersize vanned and showed a small proportion of mineral.

Table on Discharge No. 2 and 1. These Wilfley tables receive most of the slimes which are discharged as so-called "dirty head water," and are susceptible to further treatment by slime table, after thickening.

The classifiers at this installation also produce, as a hutch product, a very high concentrate which assays 12 oz. gold, 50% lead, 5% zinc, 4% silica. It will thus be seen that the classifiers at the Tomboy mill have three different functions, each of great value in itself, as follows:

First—They feed the tables with six separate and distinct classes of pulp, three of which carry no slimes whatever.

Second—They save a great deal of valuable amalgam which has escaped the plates, the special amalgamators and the mercury traps, and which would probably be lost to a considerable extent if fed to the tables.

Third—They produce a very high-grade shipping concentrate directly from the hutches.

UNITED RICO MINES CO.

The ore which this company treats in its mill at Rico, Colorado, is of a very complex nature, as shown by assay of the feed to the classifier, hereinafter given. A standard 4-inch 6-compartment Richards Pulsator Classifier was installed in the latter part of 1908. Unfortunately the mill was partially destroyed by fire five days after the classifier was put in operation, and in all probability the operators had not become sufficiently conversant with the machine to arrive upon the best adjustment thereof for their particular ore during the five days the machine was in operation.

Nevertheless the results obtained were highly satisfactory, and the table treating discharge No. 3 produced a zinc concentrate which assayed 42 per cent. zinc—a thing not heretofore accomplished on Rico ores without magnetic separation of the zinc and iron values.

The following assays of the classifier feed and product at the mill, were furnished by Mr. J. M. McClave and are of great interest. Note the preponderance of lead values in the coarse products and of zinc values in the fine products:

	LEAD.	ZINC.	IRON.	INSOLUBLE.
Feed to Classifier	10.0%	24.3%	10.5%	12.7%
Discharge No. 1	9.9	23.8	11.0	14.0
Discharge No. 2	11.2	22.8	11.1	12.6
Discharge No. 3	8.7	23.0	11.0	14.1
Discharge No. 4	4.2	22.6	9.3	25.4
Discharge No. 5	9.2	23.6	14.6	15.2
Discharge No. 6	32.9	17.3	14.9	2.5
Safety Spigot or Discharge No. 7	43.9	12.5	12.7	2.4

The assays thus given show how the classifier, by its jig-like action, increases the lead content in the feed to coarse tables and this should be of particular interest to those who mill ores which are low in lead content.

The enrichment of the feed to the coarse tables insures that these tables will produce a high-grade concentrate for which a correspondingly high price per unit will be paid by the ore purchaser.

For instance, we know of one mill treating a complex ore averaging about 1½ per cent. lead and producing concentrates which average 20 per cent. lead. Now if by means of a Richards Pulsator Classifier, a part of this lead were recovered as a 40 per cent. concentrate, the shipper would be paid 51 cents per unit less a treatment charge of only $2.50 per ton, whereas as it is, he receives but 45 cents a unit less a treatment charge of $4.50 per ton for all of his lead concentrates.

DIMENSIONS OF RICHARDS PULSATOR CLASSIFIERS
INVERTED TYPE

DIMENSIONS IN INCHES. APPROXIMATE ONLY

SIZE	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
3-in. 6-Compartm't	43	51	28	78	26	12½	8	8	12	13	7½	50	1	14	4
4-in. 6-Compartm't	48	69	33	85	34	14½	9	10	13	17	11	65	2	18	5

3-IN. AND 4-IN. CLASSIFIERS HAVE 12X2¾-IN. PULLEY. 160 R.P.M. MAY RUN IN EITHER DIRECTION

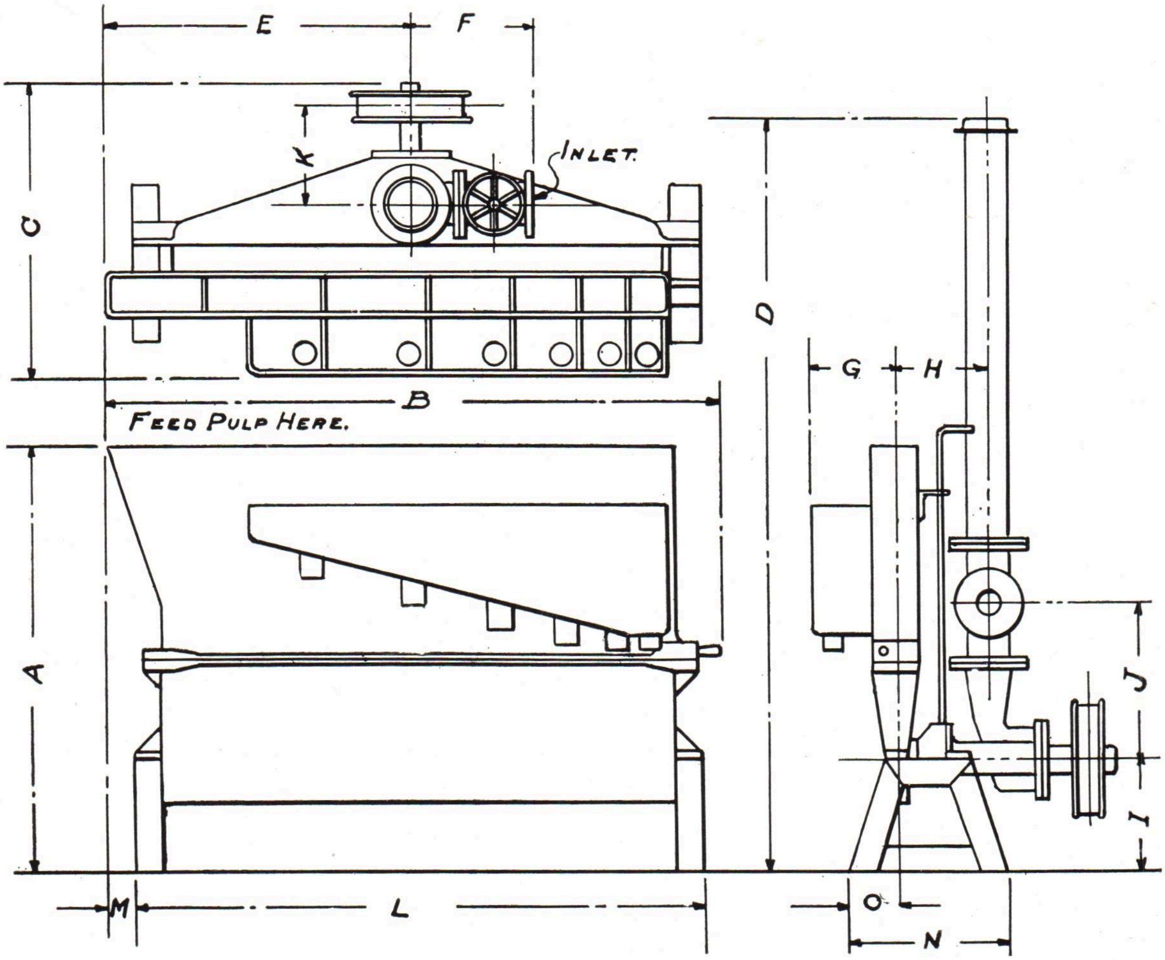
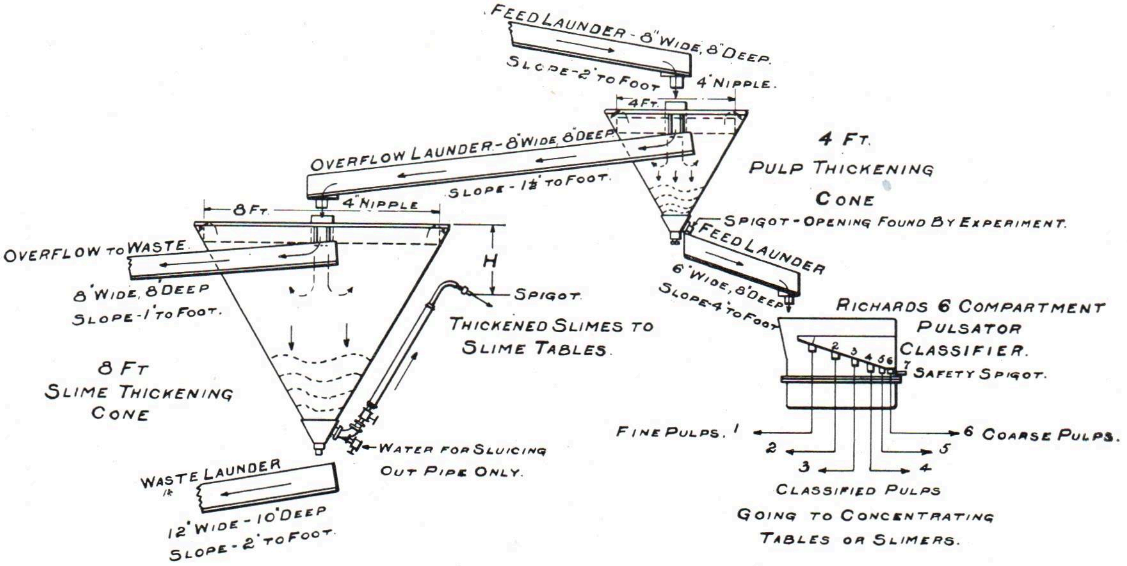


FIG. 0224

ARRANGEMENT FOR PROPER CLASSIFIER FEED


Feed Launder - 8" Wide, 8" Deep.
Slope - 2" to Foot
4" Nipple.
4 Ft.
4 Ft. Pulp Thickening Cone
Overflow Launder - 8" Wide, 8" Deep
Slope - 1½" to Foot.
8 Ft.
4" Nipple
Overflow to Waste.
8" Wide, 8" Deep
Slope - 1" to Foot.
H
Spigot.
Thickened Slimes to Slime Tables.
8 Ft Slime Thickening Cone
Water for Sluicing Out Pipe Only.
Waste Launder
12" Wide - 10" Deep
Slope - 2" to Foot.
Spigot - Opening Found By Experiment.
Feed Launder
6" Wide, 8" Deep
Slope - 4" to Foot
Richards 6 Compartment Pulsator Classifier.
1 2 3 4 5 6 7
Safety Spigot.
Fine Pulps. 1
2
3
4
5
6 Coarse Pulps.
Classified Pulps Going to Concentrating Tables or Slimers.

Arrangement of Pulp Thickening Cones to Insure a Proper Feed to the Richards Pulsator Classifier.

FIG. 0225

HOW TO FEED CLASSIFIER FROM PULP THICKENING CONES

If the pulp is not sufficiently thick to feed to the classifier then the proper arrangement of pulp thickening cones is shown in Fig. 0225.

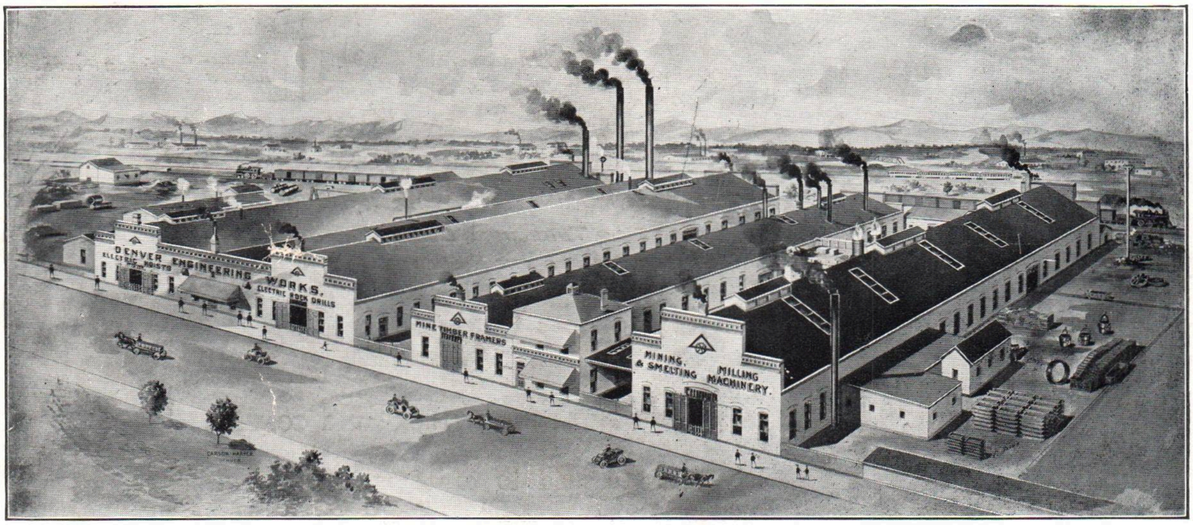
The four-foot diameter pulp thickening cone delivers thickened pulp from the bottom spigot, the opening in which must be found by experiment, but will probably be between ⅜″ and ⅞″ diameter. The overflow from the four-foot pulp thickening cone carries the surplus water and slimes, which are in turn thickened in the eight-foot slime thickening cone. A siphon spigot is provided with this eight-foot cone to save fall in the mill. The head "H" may be varied to suit different pulps.

The diameter of the hole in the wooden spigot of the siphon discharge pipe will vary from 3-16″ to ⅜″, depending on condition of pulp.

The overflow from the eight-foot slime thickening cone will be clear, or nearly so, and may go to waste or to a settling pond from which the clarified water may be returned to the mill system.

The Richards Pulsator Classifier is patented in the United States and all the principal foreign countries.

DENVER ENGINEERING WORKS.



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